

SECTION OF ENTOMOLOGY

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Presidential Address

ENTOMOLOGY IN INDIA: PAST, PRESENT AND FUTURE.

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I. INTRODUCTION.

It is my very pleasant duty to extend, on behalf of the Entomologists in India, a most hearty and cordial welcome to our comrades from across the seas—the Delegates of the British Association for the Advancement of Science. In the development of entomology in India, the British Scientists have played a very important part. Let us hope that their association in our deliberations this year is yet another bond that will unite us still closer for rapid advancement of entomology and service to mankind. In our efforts to learn everything about insects and, through knowledge thus obtained, to bring them under control, we are engaged in one of the greatest and noblest of all undertakings, not for the benefit of a community, or a class of people, but for all humanity.

We must be happy that after 24 years of steady growth as a branch of zoology and in the service of agriculture, medicine and veterinary, entomology has established a claim for full independence. A similar status entomology has enjoyed in International deliberations since 1910, when the First International Congress of Entomology was held at Brussels, and within the Empire entomology has been 'self-governing' since 1920, when the first Imperial Entomological Conference was held in London. Having taken birth on the auspicious occasion of the Jubilee Session of the Indian Science Congress, the future success of this new Section seems assured.

I am deeply conscious of the honour done me in inviting me to preside over the first session of the Section of Entomology and I am equally conscious of the great responsibility that rests upon me, because does not the poet say :

'The first brick if a mason lays untrue,
The wall to sky if built shall rise untrue.'

I have, therefore, attempted to trace briefly the history of Entomology in India, and have ventured to offer for your consideration, some suggestions for the future development of the science to which we owe allegiance: so that the first stone be laid well and true. It is an ambitious task and I am fully conscious of its magnitude. I, therefore, crave your indulgence.

II. ENTOMOLOGY IN ANCIENT INDIA.

It is evident that man's association with insects dates back some 500,000 years, when our hoary ancestor hobbled clumsily on mother earth. His interest in insects was two-fold: they formed an occasional source of his food—spicy, crisp morsels, and 'they irritated him by day and disturbed his slumber by night'. It is certain that he must have adopted the simple method of 'hand-picking' to capture insects that formed his savoury food, and to rid himself of noxious vermin.

Coming to the period of which we have recorded history, we find the association between insects and man already well-established, mostly as bitter foes, though here and there as friends. The more ancient a civilization, the more closely interwoven this association. Hence India contests with China the claim of having domesticated the silkworm. It has been chronicled that in the year 3870 B.C. an Indian King sent as presents various silken stuffs to a Persian ruler. It must, therefore, be assumed that our forefathers were already well-versed in the manufacture of silk cloth, some 6,000 years ago (Bolle, 1917). They certainly knew how silk was spun by the silkworm, because Yajnavalkyasmati illustrates the creation of the world by God from Himself 'as the silkworm creates the cocoon from its own

saliva'. Our ancient sages must have made careful observations on the life-history and propagation of this insect before they were able to place the silk industry on a sound basis.

Similarly, lac has been 'cultivated' in India from pre-historic times. It has been in use both as a dye and as a resin for thousands of years. It is mentioned in the Mahabharata, in the Adi-Parva, that the Kauravas sought the assistance of Purochak—an architect of fame, to construct such a house as would destroy their enemy kinsmen the Pandavas. Purochak constructed a house of lac—a highly inflammable material (Misra, 1923). The Pandavas getting a timely warning, however, escaped the calamity.

References to honey-bee are very copious in ancient Sanskrit literature, honey being used as food and in rituals. It is interesting to find that the 'black-bee' was described as a stinging insect with six legs and given the name Ṣaṭ-pada—six legged (*Amarkosa*, 1st century A.D.), hundreds of years before P. A. Latreille (1825) invented the term Hexa-poda.

There is abundant evidence to show that ancient Indians devoted considerable attention to the discovery of the medicinal properties of insects. Undoubtedly this must have entailed careful researches and extensive and elaborate observations, continued over hundreds of years. There are also abundant references in ancient books of medicine to insect tormenters of man and various remedial and preventive measures have been suggested, some of which have survived to the present day. The use of *chauri*, now a mere symbol of dignity and regalia of royalty, must have originated as a measure of warding off the attentions of flies. And, burning incenses in temples, and during religious ceremonials, to please the deities, probably had its origin as repellents against mosquitoes and similar other insects seeking refuge in the dark, cool and humid interiors of the temples. We have frequent mention in Sanskrit medical works of the repellent properties of incenses and in *Matsyapurana* an incense so potent is mentioned that where it is burnt 'no insect will be seen there, neither frogs nor snakes'.

Calamities such as insect plagues have been regarded (and are still regarded among certain people), as manifestations of Divine wrath for the chastisement of man for his misdeeds. Visitations of lice, flies and locusts mentioned in Exodus came as punishments to the Pharaohs. The consequences of sin could only be averted through repentance and prayer, and therefore the aid of the priest became necessary in insect control.¹

¹ Weiss (1937) has recently contributed an interesting article on 'Criminal Prosecution of Insects' in which he has given instances of certain law suits being instituted against insect pests and supernatural aid of Church invoked for their destruction. This went on even up to the 18th century.

There are hymns in Atharva-Veda¹ concerning the control of insect pests of crops, animals and human beings. Whether these methods of exorcism, sacerdotal conjuring and cursing were considered sufficiently potent or were employed as aid to more direct methods, we cannot say.

These hymns, however, give an insight into the variety of pests that had to be destroyed, the thoroughness of destruction that was aimed at, and the revenge which was contemplated against worms, providing abundant proof of the seriousness of the situation.

In Europe the scientific study of insects has been traced back to Aristotle (384–320 B.C.). It cannot be denied that long before his time Indian learning had reached a very advanced standard, but we are ignorant of the entomological observations of the Indian contemporaries of Aristotle, Pliny (23–79 A.D.) and others. Further researches in the ancient lore of our land may bring to light many facts of entomological interest. Observations about ants and their behaviour, salvaged by Moses (1928) from folk-lore, are an earnest of what remains to be discovered. One may commend such researches, in a field as yet completely unexplored, to some entomologically minded scholars of our classics.

¹ *Spells against worms* (from Atharva-Veda).

- (1) The great mill-stone that is Indra's bruiser of every worm—
with that I mash together the worm, as *khalva*-grains with
a mill-stone.
 - (2) The seen, the unseen one have I bruised, also the *kururu* have
I bruised; all the *algāṇḍus* the *ṣalūnas*, the worms we grind
up with our spell.
 - (3) I smite *algāṇḍus* with a great deadly weapon; burnt, unburnt,
they have become sapless, those left, not-left I draw down
by my spell, that no one of the worm be left.
 - (4) The one along the entrails, the one in the head, likewise the
worms in the ribs, the *avaskayā*, the *vyadhvarā*—the worm
we grind up with our spell.
 - (5) The worms that are in the mountains, in the woods, in the
herbs, in the cattles, within the waters, that have entered
ourselves—that whole generation of worm I smite.
-
- (3) Like *Atri* I slay you, O worms, like *Kanva*, like *Jamadagni*,
with the incantation of *Agastya* I mash together the worms.
 - (4) Slain is the King of the worms also the chief of them is slain,
slain is the worm, having its mother slain, its brother slain,
its sister slain.
 - (5) Slain are its neighbours, slain its further neighbours, also
those that are petty as it were all those worms are slain.
 - (6) I crush up thy two horns, with which thou thrustest I split thy
receptacle, which is thy poison holder,

III. ENTOMOLOGY IN MODERN INDIA.

TAXONOMY.

In so far as taxonomic entomology is concerned, its foundation was laid by Linnæus, and in the 10th edition of his 'Systema Naturæ' (1758), he included 12 Indian insects. During the next thirty years insect collections, made mostly by Christian Missionaries, had been sent to Europe, and Fabricius in his 'Entomologia Systematica' (1792-98) was able to include over 1,000 Indian species. Donovan's 'Natural History of Insects in India' was started in 1800. It was based on the collections of Francillon, Drury, MacLeay, Sir J. Banks and Donovan himself. Fabricius also had examined these collections. Among the collectors of the period prior to 1831 may be mentioned, among others, the names of General Hardwicke, Capt. Smee, Messrs. Saunders, Royle, and Downs. The second edition of Donovan's book, revised by Westwood was published in 1842, and Westwood's 'Cabinet of Oriental Entomology' appeared in 1847. These publications are unrivalled for the beauty of their coloured plates.

The Asiatic Society of Bengal.

The Asiatic Society of Bengal was established in 1785 and under its auspices insect collections and knowledge about insects began to accumulate. The various publications of the Society contain much valuable entomological literature. Of the efforts made to encourage scientific enquiry and to disseminate scientific knowledge, those of Lord Auckland, patron of the Society about 1836, deserve special mention. He arranged informal social gatherings for the purpose and on the 9th November, 1836, for the first time, the Governor General's Conversazione was held and 'Natural Philosophy took its place among the social recreations of the Government house'. 'A very splendid collection of insects was seen displayed on the tables and against the walls, in convenient cabinets: the newest addition to these (which comprised a portion of Dr. Pearson's and of the Asiatic Society Cabinets) was the donation of Mr. George Loch of the Civil Service to the Asiatic Society at a recent meeting' (Journal Asiatic Society of Bengal, 1936). Incidentally this shows that insect collections were being presented to the Society early in its history.

All through the 19th century taxonomic study of Indian insects received a good deal of attention and the entomological publications of that period contain a vast amount of scattered information, mostly based on the collections made in India by enthusiastic foreign amateurs, and sent to specialists in Europe for identification.

The last quarter of the 19th century is, however, of very great importance in the history of entomology in India. It was during this period that entomological work began to be actually done in the country. The Indian Museum was established in 1875, the Bombay Natural History Society in 1883, and about this time, the 'Fauna of British India' began to appear. It was during this period that Ross was making history in Medical Entomology and the foundation of Agricultural Entomology was being laid by Cotes and others.

The Indian Museum, Calcutta.

On the establishment of the Indian Museum, Calcutta in 1875, the entire collection of the Asiatic Society of Bengal was handed over to the Museum. Cotes (1896), however, informs us that, 'unlike the other portions of the Indian Museum the Entomological Section did not receive any large contingent of specimens from the Asiatic Society of Bengal', and that 'it was not until Dr. Anderson (1865-1886) was appointed Curator that any persistent attempt seems to have been made to gather together representatives of the general insect fauna of India'. Cotes tells us that previous to his appointment in 1884 the insect collection was under the care of Wood-Mason, Nevill and de Niceville, and it consisted mainly of the specimens collected by de Roepstorff from the Andaman and Nicobar islands, by Wood-Mason from Andaman and Cachar, by Peal from Assam and by Young from Kulu. Dr. Ferdinand Stoliczka had bequeathed to the Museum a considerable collection of Rhynchota. Lionel de Niceville's set of butterflies was the finest that the Museum possessed. There were some named Indian Coleoptera, in a bad state of preservation, which had been received from the Museum of the East India Company in London. There was a fine series of the Mantidæ collected and named by Wood-Mason and a few Phasmids. There was also a miscellaneous collection made by Indian collectors employed by the Museum in various parts of India.

Cotes (1896) states that in 1884 the number of specimens in the Museum was less than, 20,000. The next decade saw rapid growth and by 1894 this collection was four-times richer in specimens. At the same time it had been sorted and classified. Cotes left in 1896.

Lionel de Niceville, who had been collecting butterflies for years, was appointed to the newly created post of Entomologist to Government of India in 1901, and put in charge of the section of Entomology at the Museum. Unfortunately he died in December 1901, and after his death the post of Entomologist to Government of India was transferred from the Museum to the Agricultural Department. All Entomological work at the Museum remained practically in abeyance until 1909 when a

new post of Assistant Superintendent in Entomology was created and F. H. Gravely appointed. He did valuable taxonomic work on certain families of the Coleoptera. Gravely was transferred to Madras in 1920. The post remained vacant up to 1923, when B. N. Chopra was appointed and on his transfer to another Section of the Museum, H. S. Pruthi took over charge of the Section of Entomology in 1925 and held it till 1934. He contributed to the taxonomic studies of the Jassidæ. Pruthi was appointed Imperial Entomologist to the Government of India, and his place at the Museum taken by Hafiz. Sharif, who held a temporary appointment in the Zoological Survey produced valuable work on fleas. The section has always remained a small one with just one Assistant Superintendent and a few Assistants.

From its very inception the Indian Museum, Calcutta has been a centre of systematic work on insects, and has today a collection of insects containing over 17,000 named species. This collection has been built up with the help of the Indian Museum staff, and collectors working in several parts of India, as well as by purchase of private collections and donations from amateurs. Among such amateurs was Lord Carmichael (Ex-Governor of Bengal) who donated a huge collection to the Indian Museum. Many of the staff of the Museum and of the Zoological Survey (established in July, 1916) were interested in entomology and have added to our knowledge of taxonomy.

The co-operation of entomologists in different parts of the world for working the Indian Museum collections had been obtained very early, and European and American entomologists have been closely associated all along with the development of taxonomic entomology in this country.

The Records and Memoirs of the Indian Museum contain much valuable material on insect taxonomy.

The Bombay Natural History Society.

The Bombay Natural History Society was founded in 1883. The members of this Society have done, from the very beginning, valuable work in entomology, particularly taxonomic entomology. The Society started the publication of a Journal in January, 1886. Much entomological literature has appeared in this periodical.

The Society commemorated its Golden Jubilee in 1933, and printed a very interesting and illuminating account of the entomological work done in India by its members.

Of the various groups of insects, butterflies have been most extensively collected and studied. Of the earliest writers and collectors of butterflies are Wood-Mason (1875-1881), Col. Swinhoe (1884), Moore (1884), and Watson (1890). Lionel de Niceville (1881-1902) and Marshall are the founders of systematic

work on Butterflies in India. Lionel de Niceville's three volumes on Butterflies had appeared between 1882-1890, the 4th volume in manuscript was purchased by the Indian Museum and placed at the disposal of Bingham who was preparing the Fauna volumes on Rhopalocera.

Bell (1896-1910) studied the life-histories of Indian Butterflies.

Of the other workers who have contributed to our knowledge of the Indian Butterflies Doherty (1889-1891), Mackinon (1896), Mrs. Robson (1895), Leslie (1903), Young (1904), Rhe Philipe (1906-1917), Andrewes (1909-1911), Betham (1909), Hannyngton (1911), Tytler (1915), Allen (1919), Ollenbach (1919), Yates (1930), Peile (1937), and Puri (1930) have done good work.

Sir George Hampson's (1888-1910) name is familiar to all students of Indian Heterocera as the author of the four volumes on Moths in the Fauna of British India. Dudgeon (1895-1906) has also described many Indian Moths. Fellows-Mansion has done good work on Sphingidæ, while Prout (1928) has published much on Geometridæ.

Meyrick's (1908-1913) work on Microlepidoptera is of outstanding merit. Fletcher's studies on the life-histories of Indian Microlepidoptera are valuable additions to our knowledge of the group.

Of the early writers on Indian Coleoptera the name of Baly (1886) stands out prominently. Little work on Indian Coleoptera appears to have been done up to 1910, when Maulik published his admirable work on Chrysomelidæ. Gravely (1913-1923) has done good work on Tenebrionidæ and Passalidæ. Gardner has done pioneer work on the systematics of the larvæ of Coleoptera. The list of present day workers on Indian Coleoptera include such familiar names as Arrow, Andrewes, Blair, Marshall and Ochs.

The first worker on Indian Hymenoptera is Wood-Mason (1875-1881). He was followed by Forel (1885-1902) who has done excellent work on Indian Formicidæ. The best work on Hymenoptera, however, is by Bingham (1888-1908) whose collections form the basis of his Fauna volumes on the Order. Nurse (1903-1914) who collected in Baluchistan and Simla also made valuable contributions to this order. Lately he presented his collections of 10,000 Hymenoptera to the British Museum.

Other workers on the group are Cameron, Turner, Hingston, Mani, Wroughton, Rama Krishna Ayyar and Uani. Mukerji, Negi, Misra and Gupta have studied the ants and the three latter in relation to the lac insect.

Giles in 1900 contributed a paper on Mosquitoes and Malaria to the Journal of the Bombay Natural History Society. This was followed by descriptions of some new species of mosquitoes by Cogill. It was, however, Theobald who wrote regularly

on Indian Culicidæ between 1906–1910. Recently Barraud and Christophers have written Fauna volumes on Indian Culicidæ. Other workers who have contributed to our knowledge of Malaria and Mosquito are Liston, Bentley and Covell. Russell has published a series of useful papers on Parasitic Diptera. Sinton has worked on the sandflies and Mitra on Culicoides. Brunetti (1907) wrote a number of papers on Diptera and published the Fauna volumes on the group. Important contributions to our knowledge of Diptera have also been made by Keiffer (1909), Bezzi (1913), Cross (1926), Edward (1932), Isaac, Bhatia and Puri.

Aitken (1884–1889) and Kirkaldy and Kershaw (1909) are the earliest writers on Indian *Rhynchota*. They were followed by Distant who wrote the Fauna volumes on Hemiptera. Green (1899) studied Coccidæ—a group of great economic importance and his 'Coccidæ of Ceylon' contains material of much value to Indian students. Karagode, Rama Krishna Ayyar, and Mahdi Hassan have also made valuable contributions to this family. Pruthi has studied Jassidæ. Das (1915) worked on the Aphididæ of Lahore, while Krishna Murti is studying the Aphididæ of Mysore. Crawford (1912) has done work on Psyllidæ and Maskell, Peal, and Lamba on Aleurodidæ.

Liston (1904) studied fleas in relation to plague. Gragg and Sharif have made systematic study of Siphonaptera.

Laidlaw (1911) started the study of Odonata and Fraser made an intensive study of Indian Dragonflies, his three Fauna volumes providing a splendid study of the order.

Wasman wrote on the Termites in 1889. Assmuth took up this work but did not complete it. His collection was later described by Holmgren. Later on Fletcher also made contributions to this very important group. Dr. Anandale also interested himself in Termite Mounds.

Wood-Mason (1875–1881) laid the foundation of the study of the order Orthoptera by his work on Phasmidæ and Mantidæ. Cotes studied the locust, *Acridium peregrinum* in 1899. Of recent workers on the order names of Giglio Tos (1914), Chopard (1911) and Uvarov deserve special mention.

Bagnall (1912) and Rama Krishna Ayyar have studied Thysanoptera.

Our knowledge of Dermaptera we owe to Burr, of Trichoptera to Dover and Uartynow, of Neuroptera to Needham, of Thysanura to Silvestri and of Collembola to Carpenter.

Number of species of insects known from India.

Blanford in 1881 put down the number of species of insects known from this country at 12,100; Lefroy (1909) attempted a similar census 28 years later and raised the figure to 29,700; in 1917 Fletcher put it at 35,000. On the basis of the information

contained in the 'Lists of publications on Indian Entomology' (1920-1934), it is estimated that over 5,000 new species have been described since 1917. It will, therefore, be safe to estimate that by now the species of Indian insects known number 40,000.

As to the number of insect species actually existing in India there has been a gradual rise in estimates. Cotes estimated twenty thousand to be a moderate computation, Fletcher (1919) raised this figure to 70,000. Sharp (1919) stated—'that no more than one-fourth of the insects existing in India are represented in any collection or even in all the collections if they could be united and brought together in one'.

The number of the existing species of the insects of the world has been variously estimated at 2·5 millions to 10 millions and the latter figure is certainly nearer the truth. India's share of the variety of insect forms cannot be less than 25 per cent. of the world's and that will bring the figure to 2·5 millions. On this basis, of the insects of our country we know only one for every sixty we know not. If the estimates of Blanford, Lefroy and Fletcher were correct then during 1881-1917 additions to the number of the species described were being made at the rate of 640 per annum, while during the last twenty years it has been about 250 per year.

Our Insect Collections.

Although we may claim that insect collecting in this country has gone on continuously for over a century and a quarter, yet the condition of our collections is unfortunately distressing. Our main general collections are at the Imperial Agricultural Research Institute, New Delhi, the Indian Museum, Calcutta, and the Forest Research Institute, Dehra Dun. There are also the collections of the Bombay Natural History Society and those of the various Medical Institutes, provincial Agricultural Colleges, some provincial Museums, local societies and some of the Universities.

Through the courtesy of the officers in-charge, I have obtained figures regarding the present condition of the three of the first named collections (see statement below). From the information available it is estimated that the number of known species in all the collections in India does not exceed 25,000. This number is 10,000 short of Fletcher's estimate of 1917 and 15,000 short of the computation now made.

Taking a few specific instances we find the position very disappointing. Distant (1902-1918) described 4,005 species of the Rhynchota (he did not deal with the Psyllidæ, Aphididæ, Aleurodiadæ and Coccidæ), but in all the main collections in India we have not more than 1,600 species represented. Thus, of the Rhynchota of our own country, all our collections put together, do not contain more than 33 per cent. of the species

Approximate number of species of Insects in different collections in India.

	Imper. Agri. Res. Inst., New Delhi.	Ind. Museum, Calcutta.	Forest Res. Inst., Dehra Dun.	Estimated number in all collections in India.
Hymenoptera ..	1,000	1,397	600	1,450
Diptera ..	2,500	3,236	400	3,500
Lepidoptera ..	8,000	6,068	3,300	8,750
Trichoptera	140
Coleoptera ..	5,000	3,617	7,000	7,500
Rhynchota ..	1,500	1,575	1,000	1,600
Neuroptera (Sensu- antiquo)	162	250	260
Orthoptera (Sensu- antiquo) ..	1,500	1,193	300	1,700
	14,500	17,391	TOTAL ..	24,760

Types of Indian Insects.

	No. of spp. described.	Types in India.		Types out- side India.		Types unaccounted for.	Remarks.
		Indian Mu- seum.	Pusa Collec- tion.	British Mu- seum.	Other foreign museums.		
FAUNA OF BRITISH INDIA.							
1. <i>Coleoptera</i> .							
(i) Chrysomelidæ (Maulik) 1919, 1926, 1936 (3 volumes) ..	1,157	24	1	675	364	111	
(ii) Lamellicornia (Arrow) 1910, 1917, 1931 (3 volumes) ..	1,041	9	..	446	477	109	
(iii) Carabidæ (Andrews) 1929, 1935 (2 volumes) ..	494	17	..	177	283	17	
2. <i>Hymenoptera</i> (Bingham) 1897, 1913, Vols. I, III. ..	1,405	17	19	139	254	976	
3. <i>Odonata</i> . (Fraser) 1933, 1934, 1936 (3 volumes) ..	536	37	1	117	292	81	For. Res. Inst. D. Dun, 3. Darjeeling, 5.

which were known from India by 1918. Let us take another instance. Fraser (1933-1936) deals with 536 species of the order Odonata in his three volumes of the Fauna of British India, and we have no more than 260 species represented in all the collections of our country, and of the types we have but 46.

It is only comparatively recently that work on Odonata was started. Of the Chrysomelidæ, Lamellicornia and Carabidæ, 2,692 species have been described in eight volumes of the Fauna of British India (1910-1936) and of these we have only 51 types in India. Of 1,982 species of the Hymenoptera included by Bingham, in his two volumes of the Fauna (1897-1913) we have only 36 types in our collections. (See statement above.)

For comparison let us study the figures for North America (Hinds, 1934). In 1932, the number of insect specimens at the National Museum of Washington was 4 million and there were 170,000 named species and 50,000 types. The Canadian Museum at Ottawa had 800,000 specimens, including 30,000 named species and 4,000 types.

The slow pace at which taxonomic work has gone on in India may be judged from the following specific instance. The Aleurodidæ are of considerable importance as pests of crops and fruit trees. Maskell, the first to study Indian Aleurodidæ, described 5 new species in 1895. Peal, 8 years later (1903) added 7 more species from India. About that time rapid progress was being made in America and Quaintance had, by 1909, listed some 160 species, and since then many more have been added. In India it was not till 1931 that Lamba made a study of this family and recorded 44 species (not including 17 already described) of which 25 were new to science. Lamba's work was based on the material collected mainly from the Pusa Estate—an area of a few square miles. An investigation carried out over the entire country will show that perhaps ten times as many more species still remain undescribed as have been described so far.

Of course there are some groups which have received greater attention than others. Mosquitoes for instance, because of their medical importance, have been collected and studied very intensively. Till about 1890 only four species of mosquitoes were known from India, but by 1917 over 200 species had been described (Fletcher, 1917), and within less than 20 years Christophers (1933), and Barraud (1934) described 315 species of Culicidæ in the Fauna of British India. Again, while in 1889 Cotes and Swinhoe catalogued 225 species of the Microlepidoptera, by 1917, i.e. within less than thirty years, well over 2,000 species had been described from India (Fletcher, 1917). These instances show what amount of work remains to be done in every group of the class Insecta.

PUBLICATIONS ON SYSTEMATIC ENTOMOLOGY.

The Fauna of British India.

Hampson's four volumes of the Fauna of British India on Heterocera (1892-1896), followed by a volume on wasps and bees (1897) by Bingham appeared during the last decade of the 19th century. The remaining 38 volumes, so far published, came out during the twentieth century, and as many as eleven volumes during the last seven years. Some of the early volumes are already out of date. A large number of orders has not yet been touched at all.

India owes a deep debt of gratitude to those British entomologists who have contributed towards this valuable record of Indian Insects. Lately, it is gratifying to note, some Indian entomologists have come forward to take their share in this national work. Maulik's volumes on Chrysomelid beetles have maintained the high standard of the series, and we are glad to see it announced that Sharif has been selected for the task of preparing volumes on fleas, lice and ticks. Let us hope that more and more of this work will be entrusted to indigenous talent, and more and more of our young entomologists will qualify to take such work in hand.

Catalogues of Indian Insects.

An insect catalogue is the dictionary of an entomologist and also his directory. At present in most cases we do not know what we possess and where it is? Without catalogues no taxonomic work is possible. Cotes when attempting to arrange the collection of moths in the Indian Museum felt the need of a catalogue. He commenced this laborious task and Col. Charles Swinhoe, who had amassed through his long service in many parts of India, one of the largest of amateur collections of Indian moths in existence, came to his help. After three years of hard labour the catalogue of moths was completed, and the Museum specimens arranged. Similarly, the work of arranging at the Indian Museum collections of different groups was taken up side by side with the work of cataloguing. Catalogue of Rhynchota by Aitkinson is one of the earliest attempts.

Catalogues, check lists, and similar other publications have appeared from time to time in the publications of the Asiatic Society of Bengal, the Indian Museum and the Zoological Survey, the Journal of the Bombay Natural History Society, the Indian Journal of Medical Research and various publications of the Imperial Department of Agriculture, and other periodicals but the credit of making a most organized attempt to publish a series of the Catalogues of Indian Insects goes to Fletcher. He placed this matter before the 3rd Meeting of the Entomologists in 1919, and his proposal received unanimous support. Government

sanctioned expenditure on these publications and the entomologists came forward to help. The first part of the Catalogue of Indian Insects was published in 1921. So far 23 parts have appeared and a few more parts are ready for publication. Of these Fletcher himself was responsible for 6 parts. However, up to date, not more than 25 families have been dealt with, the total number of families recognized by Fletcher (1926) being 495. This just shows how far we have lagged behind in this work, and what tremendous concerted and co-operative efforts we must make in this direction.

In the past much valuable taxonomic work has been done by amateurs, staff of the Indian Museum (now Zoological Survey of India), medical entomologists and the entomologists in the Agriculture and Forest Departments.

Pure Entomology—other aspects.

Exceedingly little work has been done in India on other aspects of pure entomology in general. It is only recently that the teachers at the Universities and their post-graduate students have selected entomological subjects for research. Mukerji and his pupils from Calcutta, George and his pupils from Bombay, Misra and his students from Benares, students of the Zoology Schools of Lahore, Lucknow and Aligarh have made valuable contributions. Vishva Nath from Lahore, Asana from Gujarat (Sind) and Bhattacharya from Allahabad have selected insects for their cytological work.

APPLIED ENTOMOLOGY.

Agricultural Entomology.

Indian Museum, Calcutta.

The first Institution that undertook applied work side by side with taxonomic work, was the Indian Museum, and till the close of the 19th century the Museum continued to be the centre of all research and information on Indian insect pests. Wood-Mason (1884-85) carried out investigations on the *Tea bug* and *Tea mite* of Assam on *Paraponyx oryzae*—a pest of rice in Burma. He answered enquiries about noxious insects and their control, addressed to him from all over the country. In 1888 Cotes undertook investigation on the wheat and rice weevils of India, and soon after the Trustees of the Indian Museum officially took upon themselves the responsibility of investigations on crop pests of India as a part of the work of the entomological section of the Museum. Circular letters inviting co-operation of officials and others resulted in the accumulation of a large quantity of material and information, particularly from the Provincial Departments of Land Records and Agriculture.

Cotes published the results of his investigations on applied entomology in the first three volumes (1884-1896) of the Indian Museum Notes—a publication specially started for the purpose. Cotes left the Museum in 1896 and the subsequent two volumes (1900, 1903) of the Indian Museum notes were compiled by Barlow (who died in 1900) and Peal.

Rapid increase in Entomological work and demand for a proper study of crop pests necessitated the creation of the post of Entomologist to Government of India. In January, 1901, as has been stated above, Lionel de Niceville was appointed to this post with headquarters at the Indian Museum. He was required to make observations on the crop pests in the field and in actual areas of their occurrence. He visited Darjeeling to study the Mosquito Blight of Tea, contracted fever and died of it in December, 1901. E. P. Stebbing officiated as Superintendent of the Indian Museum for sometime during 1903 and he published Part I of the sixth volume of the Indian Museum Notes. This was the last publication on Economic Entomology from the Indian Museum.

Imperial Agricultural Research Institute, Pusa.

H. Maxwell Lefroy succeeded de Niceville as Entomologist to Government of India in 1903 and was stationed at Surat for the study of cotton pests. In 1905, when Lord Curzon reorganized the Department of Agriculture, a Central Agricultural Research Institute was started at Pusa and Lefroy transferred there as Imperial Entomologist to the Government of India. Lefroy came to India as a young man, 'insistent and forceful', full of enthusiasm and energy. He set out to build a collection, studied the life-histories of insects, and devised control measures against insect pests. The progress made by him and his co-workers was indeed phenomenal. Three years after his arrival in India Lefroy published his most useful book 'Indian Insect Pests' (1906), and after another three years his classical work on Indian Entomology 'Indian Insect Life' (1909), [unfortunately now out of print], covering 786 pages, containing 536 diagrams and 84 beautiful coloured plates. This book is a monument to the knowledge, energy and industry of Lefroy and his co-workers of that period.¹ In 1912, Lefroy left India, though fortunately he was not lost to Indian Entomology. At the Imperial College of Science and Technology he trained a number of Indian Entomologists and his deep interest in India and her Entomological problems continued. He visited India again in 1915-16 and wrote a comprehensive report on Sericulture. Those who have had the privilege of working in his laboratory at the Imperial

¹ Misra, Ghosh, Dutt, Naoroji.

College of Science would remember his contagious enthusiasm for entomology. Lefroy was associated in his work by Howlett, a man of brilliant intellect and charming personality, an original thinker and an excellent artist. Howlett joined as Second Imperial Entomologist in 1907 (in 1912 the designation of the post was altered to that of Imperial Pathological Entomologist). Howlett died in August, 1920.

T. Bainbriggs Fletcher joined in April, 1910 as Supernumerary Entomologist and was transferred to Madras as Entomologist to Government in April, 1912. He returned to Pusa in December, 1913 as Imperial Entomologist and held that post till 1932. During his time insect taxonomy received the greatest attention at Pusa and he built up a splendid library and a valuable collection particularly of the order Lepidoptera.

C. W. Mason (1912) joined as Supernumerary Entomologist and during his short term of service he did valuable work on the birds of Pusa. (Mem. Dept. Agric. India, No. 3.)

Howlett's place was taken by Isaac in June, 1922 as Second Entomologist (Dipterist).

Fletcher (1917) submitted to the Indian Industrial Commission of 1916-18 an elaborate scheme to set up a Central Organization for all pure and applied work including medical, veterinary, agricultural and forest entomology, in India. This Bureau was to consist of 20 expert entomologists, 23 Entomological Assistants with necessary staff. The non-recurring expenditure on building, etc. was estimated at about Rs.14,00,000 and the annual recurring expenditure at Rs.4,41,900. The Industrial Commission gave their support to the scheme, but because of the changes in the organization of the administration of the country, by which Agriculture, Medicine and Veterinary became transferred subjects under the Provincial governments, and partly because of the magnitude of the scheme, it did not receive consideration from Government.

Fletcher's place as Imperial Entomologist was taken by Hem Singh Pruthi in 1934.

During the last 30 years or so several thousands of Indian insects have been reared in the Insectary of the Imperial Agricultural Research Institute at Pusa and illustrations, mostly coloured, of their life stages made. Several monographs on the life-histories of the more important groups—for example, Microlepidoptera, Hymenoptera, Coleoptera, Diptera, etc. have been published. Considerable amount of research work on several serious pests of Indian crops has been conducted. Boll-worms of cotton, Borers and Hoppers of sugarcane, pests of fruits, etc. etc. have been studied. Investigations on Termites, stored grain pests and insectivorous birds have also been undertaken. The results of these investigations have appeared as Memoirs of the Department of Agriculture in India and Bulletins of Agricultural Research Institute, Pusa.

Agricultural Entomology in the Provinces.¹

It was in 1905 that Mr. Sly in his proposals for the development of Agriculture provided for a qualified Entomologist in each province. The Secretary of State for India, however, negatived this proposal. In 1909 there were only 13 Entomological Assistants in the provinces, by 1910 this number had increased to 16—5 for teaching and 11 for field work. It was not till 1912 that a Government Entomologist was appointed in Madras, the Punjab followed in 1919 and the U.P. in 1922. In these three provinces Entomological work developed and expanded. A class II Officer was appointed in Nagpur in 1931 but the section is yet a one man show. Bombay, Bengal, Bihar, Orissa, Assam, Sindh, North-West Frontier Provinces, and Baluchistan still continue to have a very small staff of Assistants for pest control.

In Madras the Entomological work was started in 1902-03 with one Upper Subordinate who worked under the Economic Botanist. This arrangement continued till 1908-09 and by then the number of Upper Subordinates had increased to three. In April, 1912 Bainbrigge Fletcher was appointed Government Entomologist, Madras. Fletcher was transferred to Pusa in December, 1913 and E. Ballard appointed Government Entomologist in January, 1914. On Ballard's retirement, Rama Chandra Rao was appointed Entomologist to Government, Madras, and held this post till December, 1930, when he took over as Deputy Locust Research Entomologist in the Locust Research Scheme of the Imperial Council of Agricultural Research. He was succeeded by Rama Krishna Ayyar, who retired in July, 1935. This veteran entomologist continues to take keen interest in entomology. Cherian is now officiating as Entomologist.

In 1914 Fletcher published his book on 'Some South Indian Insects' and brought together all the available information on South Indian insects and other crop pests, with useful chapters on applied entomology.

Entomological work was started in the U.P. as early as 1906 with the appointment of one Assistant, placed under a Deputy Director of Agriculture. A regular Entomological Section was created in 1921 and P. B. Richard appointed Entomologist to Government. The main problem of the Entomological Section has been the control of Pink Bollworm. For this investigation the Indian Central Cotton Committee gave, during the years 1922 to 1934, a grant of Rs.1,46,731.

The Entomological Section in the Punjab came into existence in 1905, and was placed under the Government Economic Botanist, Lyallpur. An Assistant Professor of Entomology was

¹ Based on the information kindly supplied by workers in the provinces.

appointed in 1908 but it was in 1913 that the Section became independent under Madan Mohan Lal. Till 1919 the staff consisted of one Assistant Professor of Entomology and three Agricultural Assistants. In September, 1919 M. Afzal Husain was appointed Entomologist to Government, Punjab. Since 1919 the Entomological Section has grown steadily and at present the staff consists of the Government Entomologist, one Assistant Entomologist, two Assistant Professors, two Research officers (one on Cotton Research Scheme financed by the Indian Central Cotton Committee) and 34 Research Assistants.

Perhaps Baluchistan was the first province where applied entomology received attention. James Cleghorn in 1890 contributed an interesting article on the melon fruit fly of Baluchistan—*Carpomyia pardalina* Bigot. The Government of Baluchistan invited Stebbing to study the borers affecting the shade and fruit trees in Quetta. In 1914 the Imperial Department of Agriculture established a Fruit Experimental Station at Quetta. However, it was not till 1932 that the Agricultural Department was organized in Baluchistan and a small Entomological staff sanctioned.

Entomological work in Indian States.

Of the Indian States, Mysore was the first to employ an Entomologist. In fact Coleman was appointed Entomologist and Mycologist in 1908 before Entomologists had been appointed in any of the provinces of British India. When Coleman was appointed Director of Agriculture, K. Kunhi Kannan, who had been associated with Coleman in his work, was appointed Entomologist and was given a staff of three Assistants. The Entomological Section of Mysore continues to maintain its tradition of useful work.

Kashmir, well known for its apples and pears, is the best locality in India for hilly fruits. Till as late as 1913 no attention was paid to insect pests of Agricultural and Horticultural importance. During this year, Ram Gopal, the then Director of Agriculture and Horticulture, discovered San Jose' Scale playing havoc with fruit. By 1921 this pest and the Woolly Aphis had been definitely identified. In 1923 the State obtained the services of Fletcher who studied the San Jose' Scale. It was in 1930 that a small Entomological Section was inaugurated.

Lately investigations have been started in Hyderabad-Deccan on the Pink Bollworm of Cotton, financed by the Indian Central Cotton Committee.

Work done in the Provinces and States.

Although some systematic work on Curculionidæ, Coccinellidæ, Parasitic Hymenoptera, Thysanoptera, Syrphidæ, and

Coccidæ has been done in Madras, the Provinces and the States have been mainly devoting their attention to the study of insect pests. Of the insect pests the following have received special attention :—*Hieroglyphus banian* Fb., *Colemania sphenaroides* Boliv., *Hispa armigera* Oliv. *Pempheres affinis* Fet., *Aulacophora abdominalis* F., *Trogoderma khapra* Arr., *Calandra oryzae*, Linn; *Schænobius bipunctifer* Wlk; *Spodoptera mauritia* Basl, *Phothorimæ opercullela*, Zell, *Earias* spp., *Platyedragoss ypiella*. Saund., *Scirphophaga nivella* Fb. *Argyria sticticraspis*, Hampson. *Pachydidiplosis oryzae*; *Chaetodacus zenatus* F., *Carpomyia vesuviana*. Bigot., Termites; *Leptocoris varicornis*. F., *Pyrilla* spp., *Idiocerus* spp. *Diaphorina citri* Kuw., *Aleurodidae*; *Eriosoma lanigerum* Haus. and other Aphididæ, *Aspidodiotus perniciosus* Comst. and other Coccidæ; and *Thrips tabacci*, Lind. In addition, these Provinces and States have also been organizing control measures against pests. Recently the Punjab has started (with a special staff of three Assistants, the strength to be increased to 6 next year) a Plant Protection Service for undertaking large scale control operations, thus separating the Research and the Field staff.

The Biological control of insects has also been receiving attention. While the Punjab and Madras have studied the parasites of *Bephantis serinopa* and *Earias* spp. respectively, Mysore has been carrying out mass production of *Trichogramma*.

The Punjab has also done considerable amount of work on the feeding habits of birds.

Further, such useful industries as sericulture, lac culture and apiculture have been receiving their due share of attention from the Imperial Institute of Agricultural Research, Provincial and State Entomologists. In all cases efforts have been and are being made to encourage these cottage industries.

Indian Central Cotton Committee and Entomological Research.

The Indian Central Cotton Committee was established in 1921 and since then many research schemes dealing with insect pests of cotton have been financed by this body. Particular mention may be made of the Pink Bollworm investigations in the Punjab and the United Provinces, the Spotted Bollworm investigations in Surat and the Punjab, the White-fly investigations in the Punjab, the *Pempheres* investigations in Madras and the Jassid investigations in the Punjab. The Indian Central Cotton Committee has so far spent over Rs.10,30,000 on Entomological Research and control of cotton pests.

In the training of Indian Entomologists the Indian Central Cotton Committee has played a very important part. Since 1922, 11 post-graduate scholars have received training in India and abroad at an approximate cost of Rs.50,000 to the Committee.

*Imperial Council of Agricultural Research and
Entomological Research.*

The Imperial Council of Agricultural Research was set up in 1929, to initiate and co-ordinate Agricultural Research on an all-India basis. It has financed various schemes of Agricultural interest costing over 85 lakhs of rupees, of which the entomological schemes had a share of Rs.7,60,450.

The very first problem which the Council took up was that of the Desert Locust—an ancient scourge of many lands. The Locust Research Scheme was started in 1930. M. Afzal Husain was in charge of the scheme as Locust Research Entomologist for 1930–1933, and was succeeded by Rama Chandra Rao in April, 1933. A portion of the staff worked on the life-history and bionomics of the Desert Locust at Lyallpur and the rest formed survey parties to determine the breeding grounds of the pest in Baluchistan, Sind and Rajputana, with headquarters at Quetta. In 1933 the scheme was divided into two parts. The headquarters of the survey portion were shifted to Karachi while the bionomics and phase problems were continued to be studied at Lyallpur. The Council has already spent about 5 lakhs of rupees on this scheme and as Sir John Russell has remarked, the results achieved are of outstanding value. A number of papers have been published. As a result of this investigation much valuable knowledge has been gained and it is certain that locust cannot be upon us without a warning, and besides, with the knowledge we possess today, warfare against this pest will be brought to a successful termination, speedily and economically.

The other important investigation under the aegis of the Imperial Council is that on the Sugarcane pests. A sum of 96 thousand rupees has been allotted for this work which is being conducted by Issac at New Delhi, with sub-stations at Karnal, Pusa and Coimbatore. Parasites of these pests are being collected with a view to investigate the possibilities of biological control.

The San Jose' Scale, an introduced pest, has spread in the submontaneous tracts of the Punjab and N.W.F.P. and has established itself in Kashmir and other fruit growing localities. The Council have initiated, under Khan A. Rahman, a survey to ascertain the distribution and incidence of San Jose' Scale and other fruit pests. A survey of Codling-moth in Baluchistan has just been concluded by the Imperial Entomologist (Hem Singh Pruthi). A scheme to determine insecticidal value of plant fish-poisons was sanctioned in 1935 at a cost of Rs.15,288 at Bangalore. A scheme for the investigation of *Pachydiplosis oryzae* has been financed, at Nagpur.

In addition to these exclusively entomological investigations, insect-life is being studied in several of the other schemes run by

the Imperial Council. The Fruit Research scheme at Chaubattia (U.P.) has an entomologist making a tree to tree survey to determine the incidence of pests and to correlate this with soil conditions. Entomological workers are associated with sugarcane investigations in various provinces.

*Indian Tea Association.*¹

Tea has always suffered from ravages of various insect pests to which Mann drew attention in 1903. It was not, however, until 1905 that an Entomological Laboratory was established at Kannykorrie (Assam) in charge of C. B. Antram. In 1911 Antram resigned and E. A. Andrewes succeeded him. Entomological work was transferred to Tocklai in 1913. Life-history of important pests of tea and their control measures have received attention. Andrewes made a very exhaustive study of *Helopeltis theivora*—'Tea Mosquito'. On account of financial world-depression the Entomological staff was reduced and Andrewes resigned his appointment in 1932. Similarly the United Planters Association of Southern India, in their Tea Scientific Department which was organized about 12 years back, undertook work on insect pests. It was about 1932 that they appointed an Entomologist. Besides *H. Theivora* the following pests of tea have received attention:—red spider *Tetranychus bioculatus*, Limacodid grubs, which have come into prominence lately, *Homona coffearia*, *Xyleborus fornicabis*, termites, *Toxoptera amantii* and a few others.

Lac Association.

Researches on lac were conducted at Pusa by C. S. Misra, and at Dehra Dun by A. D. Imms and N. C. Chatterjee; and A. B. Misra shared his father's enthusiasm and also did valuable researches on the lac insect.

The Government of India appointed a Commission in 1921 to report on the condition of lac cultivation and as a result of their recommendation established in 1925 the Indian Lac Research Institute at Ranchi with (Mrs.) Dorothy Norris as the first Director. On her retirement Sen was appointed Director.

The Institution is engaged in finding out the improved methods of cultivation as well as industrial uses of lac and shellac. Predators and parasites of the lac insect are also receiving attention. Glover, Gupta, Misra and Negi have done valuable work. Work has also been done in some other parts of India.

¹ Information kindly supplied by Carpenter and Anand Rao (Entomologist).

Forest Entomology.¹

Simultaneously with the development of Agricultural Entomology, the insects attacking forest trees were receiving attention, and there are numerous references to forest insects in the Indian Museum Notes. In 1898 E. P. Stebbing published a booklet on Forest Insects. He was appointed Imperial Forest Entomologist in 1900, and when the Imperial Forest Research Institute was established at Dehra Dun in 1906, Stebbing was appointed Forest Zoologist. He was able to make an extensive survey of Forest Insects, chiefly of the Insect Fauna of *Shorea robusta* and the conifers. In 1909 he left India. In 1914 appeared his excellent book on 'Indian Forest Insects'.

Imms was appointed Forest Zoologist in 1911 and, within his short term of office of 16 months, he did valuable research work and laid the foundation of an authentically identified insect collection, a good library, and an adequate laboratory equipment, the three essential requirements for research. C. F. C. Beeson was appointed Forest Zoologist in 1913 (the designation of this post was later changed to Forest Entomologist). During Beeson's term forest entomology made good progress, and a systematist was added to the staff. M. Cameron was appointed Systematic Entomologist in 1920 and was succeeded in 1923 by J. C. M. Gardner. Many insect pests of Forest trees have been studied and control measures devised. Ecological standpoint has received particular attention. *Hoplocerambyx spinicornis* Newm. the heartwood borer of *Shorea robusta* has been controlled by an ingenious device of trap-trees felled at the time of the flight period of the beetles. Biological control of defoliators of teak, 'Shisham' (*Dalbergia sissoo*), and mulberry has been taken up as a special line of investigation. An intensive survey of the fauna of sandal tree was undertaken in connection with the Spike disease (Beeson, Chatterjee and others).

Considerable advances have been made in systematic entomology, and a reference collection of 15,657 species has been built up, and further additions are being made every year. Gardner has paid particular attention to the classification of the coleopterous larvæ, and similar work on the lepidopterous larvæ is in progress. The results of these investigations have appeared in the Indian Forest Records, of which a separate Entomological series has been started lately.

Medical Entomology.

Medical Entomology provides the most dramatic and glorious chapter in the history of applied entomology. It is only forty years ago that insects were first incriminated as agents

¹ Based on the information kindly supplied by Gardner.

in disseminating human and animal diseases and since then discovery has followed discovery in rapid succession, and the results of these discoveries have been of utmost importance to humanity.

India has made valuable contributions. Ronald Ross, in 1898 discovered the developmental stages of the bird-malaria in the gut of a culicine mosquito, and announced to the world his discovery that certain 'dapple-winged mosquitoes' were the carriers of malaria. Immediately a Commission to investigate the malaria problem was appointed. Daniel, one of the members of this Commission, arrived in India in December, 1898 to substantiate the findings of Ross. By 1900 the Anopheline mosquitoes as vectors of human malaria had been conclusively implicated and had already attracted the attention of Austin, Giles, James and Liston. Giles advocated the desirability of a thorough investigation on the Indian Culicidæ and invited workers to send him specimens.

Partly through the discoveries of Ross, and the group of eminent workers that followed him, and partly because of the importance of malaria to India, the largest amount of entomological work has been done on mosquitoes. Theobald had obtained, in 1900, collections of biting insects of India and described the mosquitoes in his 'Culicidæ of the World', the first volume of which was published in 1901. Stephens and Christophers, member of the Malaria Commission arrived in 1901 and started their Entomological investigations. In 1904 James and Liston wrote their classical work giving descriptions of the species of *Anopheles*. In 1905 Christophers wrote a Memoir on the Importance of Larval Characters in the Classification of Mosquitoes. The Imperial Malaria Conference, at its first meeting, held in 1909 recommended the creation of a Central Scientific Committee to carry out routine work on the distribution and bionomics of the different species of *Anopheles*. In 1910 the Central Malaria Bureau was started and field laboratories were added to carry out research work on mosquitoes and malaria.

At this period (1911) an important step was taken which greatly helped the development of medical entomology in India, viz., the Indian Research Fund Association was organized to supervise and finance research enquiries into various human diseases and also on important entomological subjects closely connected therewith. Ever since its inception the Indian Research Fund Association has been financing, with the grants received from the Government of India, enquiries on entomological problems connected with the transmission and eradication of malaria, oriental sore, kala-azar, plague, etc. etc.

In 1913 Patton and Cragg published their comprehensive Text-book on Medical Entomology and the Indian Research Fund Association started the Indian Journal of Medical Research.

Prior to this the results of various enquiries were being published either scientific memoirs or reports of commissions, those directly connected with malaria appeared in the *Paludism*, a journal started for the purpose.

Work on mosquitoes continued and in 1921 a taxonomic inquiry was started under Barraud, and in 1926 Puri started investigations on the comparative anatomy of the larvæ of the Indian Anopheline mosquitoes, and made important contributions. The Ross Field Experimental Station was started at Karnal to carry out investigations on the bionomics of mosquitoes and similar work started at Delhi. In Bengal and Assam Strickland and Iyengar were making valuable contributions to the problems of the distribution and habits of the different species of *Anopheles*.

In 1933 was published Christophers' volume of the *Fauna* of British India on Anophelini, dealing with 43 species and a year later Barraud's volume on Megarhinini and Culicini dealing with 272 species.

Insect carriers of other diseases had not been ignored. Ross worked in Assam to establish the mode of transmission of Kala Azar. However, it was not until the opening of the King Institute of Preventive Medicine at Guindy, Madras, that any entomological work in connection with Kala Azar was taken in hand. Patton in 1904 started experiments on the transmission of Kala Azar with lice and bed-bug. From 1924-32 the Kala Azar Commission, under Christophers and Shortt, carried out investigations on the bionomics and anatomy of *Phlebotomus argentipes*, a probable vector of Kala Azar and Oriental Sore. Sinton has made valuable contributions to the taxonomic studies of the Indian species of the genus *Phlebotomus*.

In 1933 the Sandfly fever became a problem of sufficient magnitude for the Military authorities in the North-West Frontier Province, to ask for the services of an entomologist and Puri studied the bionomics and control of these insects under field conditions. Once again, a year or so after the earthquake at Quetta, there was a severe outbreak of Oriental Sore and the Indian Research Fund Association instituted an enquiry under Smith to investigate the causes of the increase in the number of Sandflies and their control.

The close connection of rat with bubonic plague was known to the Moghals. However, it was not till 1898 that Simond had succeeded in transmitting plague from a stricken rat to a healthy one, through the agency of an infected flea. In 1904 Liston working in Bombay confirmed Simond's observations and in 1905 the plague Commission was appointed. Taxonomic work on fleas was done by Jordon and Rothschild in England; Bacot carried out researches on the bionomics of these insects at the Lister Institute; transmission experiment were undertaken at Bombay by Liston, Lamb, Kundhart, and Chitre.

In 1907 Mackie had found that the Asiatic Relapsing fever was transmitted by the body louse—*Pediculus*. In 1934 Typhus attracted attention and Mehta is doing useful entomological work in connection with this disease.

Christopher's early work on the anatomy and histology of tick, Patton's work on Muscidae and Cragg's on blood sucking insects, particularly the bed-bug are worth mentioning. In 1914 P. R. Awati, the first 'non-medical' entomologist to join the Medical Research Department, started his work on the taxonomy of the genus *Musca* and the bionomics of the house-fly. Mitter worked on Culicoides and Brunetti (1911) described a number of new species of *Simulium*. Puri took up the taxonomic study of Simuliidae.

The credit for rapid and phenomenal progress in medical entomology and the excellent taxonomic work on insects of medical importance, goes mainly to medical men, particularly of the Indian Medical Service, who applied their well trained and disciplined intellect to the problems of entomology. Of the non-medical workers, Howlett, Barraud, Awati, Prashad, Senior-White, Iyanger, Puri and Mehta have produced work of value.

At the School of Tropical Medicine, Calcutta, Strickland was appointed the first Professor of Medical Entomology in 1922. Excellent courses in entomology are given and valuable researches conducted, on all aspects of medical entomology, especially on mosquitoes.

The entomological problems are becoming more and more complicated, and a pre-requisite for their successful solution is a broad and thorough entomological training. As Howard (1925) has pointed out there is need for the study of all insects of medical importance without an eye for immediate results, so that we discover all about them and then apply our knowledge for their control.

Veterinary Entomology.¹

While India has made important contributions to Medical Entomology, exceedingly little work has been done on insects in relation to domestic animals.

Veterinary Entomology may be said to have taken its birth in 1893 with the fundamental discovery of Smith and Kilbourn, in America, that the tick *Boophilus annulatus* was the intermediate host of *Babesia bigemina*, the causal organism of the Texas cattle fever. Two years later Bruce (1895), in Africa, found that the tsetse fly—*Glossina morsitans*, was responsible for the transmission of *Trypanosoma brucei*, the causal organism of Nagana. The causal organism of Surra, the foul disease

¹ Based on information kindly supplied by Sen.

of cattle, horses and camels in India, being a trypanosome—*T. evansi*, the attention of veterinary officers in this country was focussed on the discovery of its possible vector or vectors. This was the beginning of Veterinary Entomology in our country. With these researches are associated the names of Lingrad (1896), Gaiger (1911), Baldrey (1911), Cross (1921-22), Kahan Singh (1925-26) and others.

Lingrad had started collecting material for the study of Veterinary Entomology, and had obtained the collaboration of E. E. Austen of the British Museum, London, for the identification of flies. In 1907 Cecil Warburton published an account of the ticks 'Infesting Domesticated Animals in India'. In the same year Lefroy published an account of 'The Biting Flies of India'.

Howlett was appointed to study the order Diptera, including those that were parasitic on domestic animals. Isaac has contributed many papers on the *Tabanidæ*. Sen has done valuable work in veterinary entomology.

Veterinary Entomology has received much help from workers engaged on insects vectors of human diseases. It is to the researches of Christophers (1907) and Shortt (1936) that we owe our knowledge of the transmission of canine piroplasmiasis (*Babesiosis canis* by *Rhipicephalus sanguineus*).

Howlett (1919) worked out a scheme for the creation of a separate organization to deal exclusively with the problems of Medical and Veterinary Entomology in this country. This organization was to consist of 10 officers and 46 assistants and the estimated cost was 4.5 lakhs as non-recurring and 2,80,000 as recurring expenditure. The First Meeting of the Veterinary Officers held in Lahore in 1917, considered and accepted the proposal and passed the following resolution:—

'That the meeting is in favour of the creation of a separate organization for the study of insect parasites of men and animals, the connection with the Civil Veterinary Department being on the lines suggested by Mr. Howlett.'

Nothing happened. The same question came up again before the Second Meeting of the Veterinary Officers held in 1923, and Bainbrigge Fletcher informed them that Howlett's proposals had been dropped, 'presumably on account of financial stringency'. The meeting then passed the following resolution.

'On account of the great importance of insects in the transmission of animal diseases, as causes of direct injury to live-stock in India, and the degree of specialization necessary for the proper appreciation of the various aspects of entomology, the staff of the Imperial Entomologist should be strengthened to the degree requisite for rendering assistance to investigators into the insect problems connected with animal diseases. Similarly, facilities should be rendered for the establishment of a staff attached either to the Imperial Entomologist, or to

the Zoological Survey of India for the study of ticks and mites concerned with animal diseases.'

There was no immediate response. However, in 1933, the post of Entomologist was created at the Imperial Veterinary Institute and S. Sen appointed. We may say that the first brick has been laid and edifice of Veterinary Entomology has yet to be erected.

Lately the Imperial Council of Agricultural Research have sanctioned a scheme for the investigation of Warble fly.

In so far as the Provinces are concerned the results of the enquiries made may be summarized briefly—'No work undertaken'.

ENTOMOLOGY IN EDUCATION.

Entomology in Schools and Colleges.

Entomology has been the Cinderella of our educational system, and, so far, this important branch of human knowledge has been fairly effectively ignored in our schools and in our colleges. Save a few lessons in vernacular text-books, Indian boys and girls are taught nothing about insects. Our children do not rear caterpillars into butterflies as children do in other countries, nor are they seen with butterfly nets indulging in insect collection, which is considered by most Indian parents, a reprehensible manifestation of cruel propensities—*Jivhattia*. Thus from his very childhood an Indian boy learns to look upon insects as untouchable creatures to be abhorred and soon develops a marked entophobia. In our high schools the knowledge of insects acquired by those few—indeed very few, who take up hygiene as a subject of examination, is restricted to a few theoretical lessons about the disease carriers. In most cases this knowledge is confined to sketchy accounts and inaccurate diagrams in cheap text-books. With actual insects, living or even dead, the students make no acquaintance and in this they faithfully follow in the foot-steps of their teachers. Does it not seem strange that in courses of domestic economy for girls, a study of household pests should not be considered essential in a country where death spreading flies and mosquitoes breed freely, where weevils eat up grain, white ants damage wood and woolly bears spoil garments? In the zoology course, at the intermediate stage the introduction to entomology is confined to an elementary account of the cockroach and perhaps the life-history of the mosquito. In our Universities the number of students taking up zoology is hardly 5 per cent. At the degree stage of zoology course a study of the mouth parts and the classification of the groups into orders of Linnaeus is considered sound education.

Some of the Indian Universities are now providing training at the M.Sc. stage to those rare beings who select Entomology as a 'special' group. But often the teaching, equipment and

atmosphere provided for such a training leave much to be desired.

Research work in Entomology is recognized for the research degrees, and useful entomological work is being turned out by some of our Universities, and Insects are very often selected for cytological investigations. Of the students of zoology who go abroad for advanced training, a very large proportion select entomology for their special study. Valuable though a training in research is, it cannot take the place of fundamental training in entomology, which has become so vast as to merit a special treatment, and an independent status of a 'full subject'.

Entomological Education in Agricultural Colleges.

Till 1919 the position of Entomology even in the Agricultural Colleges of this pre-eminently Agricultural country was so unsatisfactory that the Third Entomological Meeting held in February 1919 discussed the question and made the following recommendation :—

'Considering the great economic importance of insect pests to Indian Agriculture we recommend that all Agricultural Colleges should make provision for the teaching of Entomology'.

Our Agricultural Institutions had been fashioned after the pre-war British pattern and it is not surprising that in 1919 the atmosphere was so adverse to Entomology that even the devotees of this science had not the courage to take a bold stand, and diluted their above recommendation by a rider. They stated: 'the aim of teaching Entomology in Provincial Agricultural Colleges should be to give the students a sufficient knowledge of entomology to be able (1) to recognise the common pests and to know something of their life-history and the control measures applicable to each, and (2) to be in a position to report intelligently regarding the occurrence of any unusual pests'. Such a training could not possibly be termed anything but 'First aids in Agricultural Entomology'. The explanation for this attitude was that in the Agricultural Colleges the aim was to train farmers and fruit growers and not entomologists. It was evidently no concern of the entomologists as to how and where the entomological workers were to be trained? Perhaps at that time the dominating idea was that an entomologist was born and not made. In his scheme of organisation of Entomological Research, Fletcher had not included entomological teaching at the Central Institute, and had consigned training in entomology in the Provincial Agricultural Colleges to the cares of subordinate entomological workers or to the visiting lecturers, delivering a few lectures.

Since then, thanks to the efforts of provincial entomologists, the position has greatly improved. All those Agricultural

Colleges which prepare students for the degree examinations in Agriculture give some training in Entomology, but with the exception of one or two colleges the standard of training is still very low. Only in a few Agricultural Colleges entomology has been regarded as of equal merit with botany and chemistry and is included among the 'principal' subjects. It is not often realized that knowledge which is superficial soon peels off and what does not soak through sufficiently deeply is lost immediately.

The University of the Panjab grants a degree of M.Sc. (Agric.) in Zoology-Entomology on the combined results of a written, and a practical examination and research thesis.

The number of men suitably qualified to conduct entomological investigations falls much short of the demand.

Entomology in Medical and Veterinary Colleges.

Like our Agricultural Colleges our Medical and Veterinary Colleges have also been modelled after the pre-war British pattern. We, however, forget that while insects may not be of much importance in a cold country such as England, the case of India is very different. According to Mackie (1925) 'the unhealthiness of the tropics and sub-tropics is not a question of heat and humidity or such physical states, but is due almost entirely to the diseases which these conditions foster, so that if we rid India from the insect borne diseases, we shall go far to bring her mortality into line with that of temperate countries'. Insects are responsible for most of the diseases which appear in epidemic form in India among human beings and domestic animals, yet a sound knowledge of the insect-carriers of diseases, is not considered to be an essential feature in the medical and veterinary education of our country. It is true that medical entomology has a place in the curriculum of study in Institutions training men in Tropical Medicine and Hygiene. But is that enough? At present entomology has no place in veterinary education.

IV. IMPORTANCE OF ENTOMOLOGY TO INDIA.

Sir Thomas H. Holland addressing the Royal Society of Arts (1926) on the 'Organization of Scientific Research throughout the Empire', said :—

'Anyone who has lived in a tropical country will be able to appreciate, as a consequence of painful personal experience, the importance as well as the magnitude of measures intended to stamp out noxious pests or to encourage friendly insects. Among the special branches of sciences of economic value to an empire with large possession within or near the tropical belt, I should regard entomology as perhaps first in importance'

Sir Mirza Ismail, Leader of the Indian Delegation at the Inter-Government Conference on Rural Hygiene, held at Bandoeng in 1937, thus expressed the condition in our motherland :—

‘Of the formidable list of diseases with which India is afflicted, malaria is certainly the one which exerts the most adverse influence on the health and prosperity of her people. Although less dramatic in its immediate effects than the great epidemic diseases, such as, plague, cholera and small-pox, malaria is a relentless scourge which is responsible for incalculable suffering and economic loss. It has been estimated that some 100,000,000 people in India suffer yearly from malaria and that, of these, at least 1,000,000 die from its direct effects. The debility, poverty and apathy caused by this disease are factors of magnitude in retarding the national, social and economic progress of the country.’

There is evidence to show that malaria was the cause of the decay of Greek and Roman civilizations and it is not surprising that *Anopheles* is the greatest obstacle in our progress.

According to Mackie (1925), ‘The amount of disease, invalidism and death which occurs every year in India from the bites of insects is enough to stagger humanity’. He maintains that the ‘enormous economic burden from the incidence of preventable disease which India has to bear is sufficient to prevent her rising to the position of importance to which her large population and great resources entitle her’. And, in India two-thirds of the preventable diseases can be attributed to insects.

In 1920 Fletcher made an estimate of the loss to India caused by the insect pests of sugarcane. ‘Taking the conservative estimate of 10 per cent. of damage by insect pests (and this is most certainly not too high a percentage)’ he placed the annual loss at over 330,000 tons of sugar, ‘roughly an annual sum of three hundred millions of rupees worth of wealth of the country goes into stomachs of insects instead of into the pockets (if they have any pockets) of the people’.

According to the Report on the Marketing of Wheat in India (1937), the total wastage caused by wheat weevils is ‘not less than about 150,000 tons, representing 1·6 per cent. of the average crop’—and on the basis of the upcountry prices of 1935–36 the loss has been estimated at about Rs.97 lakhs. This is but loss to one food grain, viz. wheat, alone. And it is certainly a very modest estimate, because Dean (1928) states that ‘such damage is frequently estimated at 5% and that the total value of the losses caused by insects injurious to stored grain and milled products in the United States of America amounts to two million dollars annually’.

The loss caused by one insect—the Ox Warble Fly, to the hides produced in this country is 1.5 crores of rupees per annum. According to Fletcher (1921), at a very conservative estimate, the annual monetary loss from insect pests to domesticated animals in India exceeds Rs.3.8 crores.

According to Sir Walter Morley Fletcher (1931), at a very modest estimate, the losses caused to India by insects that attack crops, timber, and animal products cannot be less than 200 crores of rupees and a loss of over a million and a half of human lives. (These figures had been officially collected for the Imperial Entomological Conference.) However staggering this may be, it cannot be considered an overestimate. Hinds (1934) estimates an annual loss to North America from insect damage at \$ 2,500,000,000, and according to Kavalev (1930) in the United States of Soviet Russia ' the enormous damage inflicted by pests upon the agriculture of the Union is estimated at over 2,000 million roubles every year '.

According to Hinds (1934) loss from insects has increased during the last 50 years and is likely to increase in the future. Every day that passes the insect problem is becoming more and more serious. It is because every step in the progress of civilization is favourable for our insect foes. The methods we employ to produce food in ever increasing quantities, to store it more and more, to produce varieties which are superior and give higher yield but are not resistant to pests, and our modes of life help insects to multiply. Facilities of transport such as motor cars, railways, aeroplanes help in insect spread.

It has been said that 'insects have been responsible for more destruction of property and loss of life than caused by all wars, floods, earthquakes, fires and famines in human history', (Hinds, 1934). A bold statement but true. On the other side we have products of insect activity which are source of wealth. India holds monopoly of lac, and silk and honey are of equally great importance.

There cannot be any doubt whatsoever that among sciences of economic value in India, entomology must take the very first place in importance ; unfortunately it occupies at present the very last.

V. FUTURE OF ENTOMOLOGY IN INDIA.

That is the present position. Now how about the future ! India has entered upon a new form of Government, with increased representation and increased responsibilities. Democracy at best is a very expensive form of administration and for all beneficent activities and developments money is essential. Retrenchments and reductions in the cost of administration are mere palliatives, they do not provide a cure. In most parts of the country the burden of taxation on land is already so high

that no further increase is possible. In fact our farmers are so heavily under debt that they are crying for immediate substantial relief. In the industrial field the competition is so keen that some form of protection or subsidy is demanded. In the circumstances we must either tap new sources of income—not an easy task, or we must stop wastage. India is paying a tribute of 200 crores of rupees to the demons '*Śaṭpada*'. What policy of defence should we inaugurate against this enemy which is destroying life and property on a scale far in excess of what any human foe can destroy. To reduce this enormous waste of our national wealth, is one of the most important and urgent problems which India has to face. It is for us to find a solution, but we are greatly handicapped. The insect problem has not yet received the recognition that its enormity demands. The number of those interested in entomology, amateurs, teachers, students, workers in pure entomology, agricultural, forest, medical, veterinary and industrial entomology, does not exceed 125. Thus for every 2·5 million people of India there is one person interested in insect study. At a very liberal estimate the total expenditure of all entomological activity—teaching, research and pest-control, would not exceed 15 lakhs a year. Against this, about 1932, the normal budget of the U.S.A. Bureau of Entomology alone was \$25,000,000 and on 1st March, 1930, the total classified personnel of the Bureau was 515, and there were 100 field laboratories in U.S.A. and other countries. In addition to this, all States and all Universities and Agricultural Colleges employed large staff of entomologists.

PUBLIC AWAKENING.

Before any progress is possible the population at large must be convinced that insects are its bitterest foes. We must have the public to appreciate the fact that it is of vital necessity that something immediate must be done to stop the inroads of insect pests. Our public must learn to appreciate the true value of the study of insect life. Our legislatures must learn to acknowledge that the insect problem is one of the problems on the proper solution of which the future of this country depends, and that applied entomology must develop if man is to gain health, peace and prosperity. It is the duty of the entomologists to educate the public and we must employ every possible method to achieve this end.

By every means possible we must greatly increase the number of workers both in pure and applied entomology. Public education will be a means to this end, and public awakening will increase the number of amateur workers, the class which has done most magnificent service to entomology in the past. Funds have to be obtained from the Legislative Assemblies and therefore

we must have the public behind us and the legislatures on our side.

FUTURE OF ENTOMOLOGY IN EDUCATION.

At the close of the Great War Sir Harry Johnston wrote an article in the *Nineteenth Century Magazine* on 'The Next War', a war against insects. In this article he rightly pleads for a wider knowledge of entomology. He boldly states that 'the whole curriculum of our schools wants overhauling and that instead of Euclid should be taught entomology or the science of insects; instead of puzzling over Algebra boys and girls should be well-grounded in elementary zoology, botany and chemistry'. In fact insect horrors so impressed him that he wanted 'all public servants of every degree and every branch of state employment' to pass an examination in entomology.

We cannot make progress unless in the words of Howard (1925) 'We uncloister our schools and colleges, not only the minds of the students but especially the minds of the teachers'. As to what should be accomplished I cannot do better than quote from Gossard (1925) who gave the following advice to the Section on Education, Extension, etc., etc., of the 10th Annual Meeting of the Pacific Coast Branch of the Association of Economic Entomologists in the United States of America :—

'This section should be specially devoted to the consideration of entomology as a necessary part of education or of nature study in rural schools, grammar schools, junior and senior schools; the inclusion of a well chosen entomological section in the Boy Scout Manual and in the publication of Campfire Girls; to secure better than casual notice on insect subjects in such papers as the Youth's Companion, Boy Life and in the standard magazines which contribute most largely to moulding the world's thoughts. It should endeavour to increase the use of entomological toys and games and if possible add to the entomological education of the clergy and those religious orders which participate in large degree in general education of the public'

No better programme could be laid for this country. Ghosh (1919) brought the same question before the 3rd Entomological Meeting and argued that no rapid progress in control of pests and noxious insects was possible unless the people of the country became 'Insect minded' and, therefore, he considered it necessary that information concerning insects be made a compulsory subject for children in primary schools in India, and advocated that the readers for use in these schools should contain simple accounts of some of the insects commonly found in the Provinces concerned, and he emphasized that Entomology should figure prominently in all courses of nature study and advised the education authorities to enlist the help of entomological workers

in the preparation of suitable readers and text-books. The meeting unanimously passed several resolutions on the subject, but so far they have remained mere pious hopes. Entomology must take its rightful place in our schools.

Entomology in General Zoology Courses.

The departments of zoology in the Universities in India have to reconsider the whole question, and impart such entomological education at all stages of a zoology course as the importance of this subject demands. We must bring education more and more in line with our needs. It is claimed for entomology that it provides full scope for the development of mind, and no other branch of zoology has such wide application to human affairs.

Entomology in Agricultural Colleges.

Although great progress has been made in some of the Universities of India to give entomology its rightful place in the curriculum of agricultural studies, yet much remains to be done. There was a time when an agricultural entomologist could be considered competent to do his work well if he was familiar with crude morphology and general classification. But gone are the days of 'catch and kill' or 'cut and burn', and we have to aim at prevention rather than cure. Insect control of today is not an easy matter, what we once thought simple is becoming more involved. Further improvement of the status of entomology in the course of agricultural studies is greatly needed.

Entomology in Medical and Veterinary Colleges.

Entomology has yet to fight its way into the curriculum of studies in our Medical and Veterinary Colleges. In a country where the so-called tropical diseases are responsible for at least two-thirds of deaths, a study of the carriers of these diseases cannot be ignored. In our country every medical institution should be a school for tropical medicine. Let us hope that the difficulty of finding time for this important branch of preventive medicine will not be insurmountable, and if it is found that the Medical curriculum is already too congested, is it not possible to make some knowledge of insect structure, bionomics and classification a qualification for admission to a Medical College?

At a meeting of the Animal Husbandry Wing of the Board of Agriculture held in 1934, the question of entomology in Veterinary colleges was considered. The opinion was favourable, although it was pointed out that in a three years' course it will not be possible to deal with the subject very thoroughly. Let us hope that something material will result.

Training of Entomologists.

The important question of the training of entomologists, as distinct from including entomology in the education of all classes of people, has been occupying the minds of teachers in all countries. The fifth Entomological Meeting held at Pusa in 1923 unanimously passed the following resolution moved by K. Kunhi Kannan :—

‘That this meeting recommends to the Indian Universities that the subject of Entomology be taught as of equal rank with other branches of biological science in the courses of studies for the examinations of the Universities for the degrees in Science including Agriculture.’

The International Congress of Entomology, held at Zurich during 1925, discussed this question. The same question came up before the Congress of Imperial Economic Entomologist, 1925, and was further discussed in the Third Annual Meeting of the British Zoologists held in January, 1926, when Prof. Stanley Gardiner moved the following resolution :—

‘That on account of the growing importance of Entomology fuller facilities for the teaching of Entomology should be provided by the Universities.’

Once again the Imperial Agricultural Research Conference, 1927 recommended :—

‘In view of the fact that the progress of Agricultural Entomology is to a considerable extent dependent on the advancement of the science of Entomology in general, it is very necessary that more attention should be given in Universities to research and teaching in pure Entomology, which are at present hampered by the lack of necessary funds.’

I do not wish to dilate on this point. I will only say that there is growing need for a better, broader and sounder training in Entomology and as a basis a wider training in Biology, which is being greatly neglected. The Universities can play a very important part in the training of entomologists, by improving the status of Entomology in their zoology course for the degree examinations and in post-graduate courses.

FUTURE OF INSECT TAXONOMY IN INDIA.

Now I come to another most important question. I would like to repeat that to be able to know precisely and definitely what insect is under investigation, and to be able to talk about it and write about it so that all others understand, is of fundamental importance in every sphere of insect study and more particularly in applied entomology. It is not every mosquito

that is the carrier of malarial parasites, nor is every fly a warble-fly. Even closely related species may have widely differing habits, and widely differing behaviour, and control operations based on imperfect knowledge of the identity of a pest may mean entire waste of enormous energy and wealth. I may perhaps illustrate this point by an example. Not very long ago the borers of sugarcane and related plants were all placed under one species, and such control measures as sowing of maize as 'trap crop', to protect sugarcane from borer attack, were advocated. It was only after a carefully taxonomic study had been made that the absolute futility of such recommendations became apparent. The borer pests of sugarcane would not feed on maize. Such instances can be multiplied indefinitely.

*The necessity of developing Taxonomic Entomology
within the Country.*

It is becoming more and more evident that taxonomy divorced from other branches of entomology cannot reach stability. Even in the case of some of our most important insect pests the past methods have led to a great deal of confusion. For instance, in practically every case the phases of the migratory locusts were named as different species. Our very serious and common pest of sugarcane in India—*Pyrrilla*—described from pinned specimens was split into three species on the basis of small colour differences which have proved to be normal variations (Pruthi, 1937). Taxonomy can no longer be regarded as mere christening of dead insects pinned, staged or preserved. Untold confusion has been caused by this attitude. With the development of applied entomology the responsibilities of taxonomy have increased. Taxonomy must be unfettered from its present bondage and allowed free vision much beyond the cabinets and museums. It is very necessary that taxonomy must be broad based and we must recognize that life-history studies, ecological observations, facts of geographical and season variations all have an important bearing on insect identification. For such a complete study of insects it is necessary that taxonomy must go hand in hand with other branches of entomology, hence the necessity of developing taxonomy within the limits of a country.

Further, the difficulties of depending on an outside agency for taxonomic work are great, in spite of the fact that we have quick means of transport and communications. I shall illustrate my point by a specific instance.

About 1927 some insects were sent abroad, and their identifications were received after about a year. There were a few new species to which names had been given, with the remarks that their descriptions would be published; but these have not

been published so far. Ten years have gone by and, as we have not been able to obtain proper identification, our publication has been held up. In the meantime another difficulty has arisen. Another consignment of the same material was sent to the same agency in 1929. As the first expert had given up work on the group, this second consignment was handed over to another taxonomist and his identifications, received recently, do not agree with the previous identifications. If it had been possible to identify this material within the country, all this delay of years in the publication of important results of wide application would have been avoided.

Imperial Institute of Entomology and Entomology in India.

While on the subject of the development of taxonomy, it will be an unforgivable omission if no mention is made of the assistance given by the Imperial Institute of Entomology, London, to workers in India. The publications of the Imperial Institute, the two series of the Review of Applied Entomology and the Insect Part of the Zoological Record, rank among the most important publications of international utility. Besides, the Institute is rendering most valuable services in the identification of insect specimens. The condition of insect collections in this country being what it is, the Imperial Institute and the British Natural History Museum have, for years, to play an important part in fostering taxonomic work in India. During the two years 1934 and 1935 the Imperial Institute of Entomology identified for India (including Burma) 1,670 specimens. How hard pressed the Institute is, will be evident from the fact that the number of insects received for identification had risen from 101,093 in 1930 to 4,926,060 in 1935. With the rapidly growing interest in entomology and particularly in applied entomology, this demand is likely to increase greatly. In addition to the staff of seven expert Entomologists on the permanent establishment, the Imperial Institute has found it necessary to seek outside help and have made arrangements with 64 specialists, in different parts of the world, to identify insects. Although this organization is the largest of its kind in existence, even so, the Institute is unable to meet adequately the demands made upon it. A mild warning has been issued by the Directorate that they have now almost reached the limit of work that is possible with their present resources.

It is not only the Imperial Institute of Entomology that is working to the utmost limits of its resources, the world position in Taxonomic Entomology is still more unsatisfactory. Of late many of the entomologists in Europe and America have drawn attention to the imminent danger of a break down. The resolutions and recommendations of the third International Congress

of Entomology held at Zurich in 1925 may be taken as an index of international opinion on this question :—

‘An enormous extension in applied entomology has recently taken place throughout the world. This has necessitated, as a first step, the exact determination of an immense number of insects. The result has been to show the utter inadequacy of the present means of undertaking such work’... ‘Everywhere the systematic specialist is overburdened and his load has now become an intolerable one.’

Attention is also drawn to a very interesting and thoughtful address by Walther Horn (1928) to the fourth International Congress of Entomology, on the ‘Future of Insect Taxonomy’, where the position of Taxonomic Entomology in the world has been discussed.

The situation does not appear to have improved during the last 12 years and Neave in his address to the Royal Entomological Society of London (1935) laid great stress on further development of taxonomic work. He stated : ‘At the present time the ever growing demand, rising from the innumerable investigations on insect pests and their insect parasites that are in progress all over the world, is quite impossible of satisfaction with the existing staff. It is, therefore, incumbent upon the Governments to spend more money in this direction (taxonomy) if they are to derive full benefits from the funds invested in solving economic problems in entomology’.

The fourth Imperial Entomological Conference held in London in September, 1935 unanimously demanded ‘the utmost possible extension of the systematic work’. It was pointed out that there was ‘still lamentable ignorance of such economically important group as the parasitic Hymenoptera and Diptera and the termites’ (Neave, 1935).

It is time that we entomologists in India carefully considered the position in relation to foreign workers and particularly in relation to the Imperial Institute. The contribution of our country to the Imperial Institute is indeed meagre—£200 a year. It should, however, be possible for us to render effective co-operation otherwise. We must develop taxonomy in this country and some of our taxonomists should specialize in certain groups and thus reciprocate the valuable assistance which has been given to us for so long by the Imperial Institute and other workers. Further, it is necessary for establishing taxonomic entomology on a sound footing in India, that a scheme of deputing at the Imperial Institute a number of young Indian entomologists for the study of special groups, for terms of years, be vigorously advocated. This will be for the mutual gain of the Imperial Institute and Entomology in India. Similarly, students going abroad for entomological education should be encouraged to do taxonomic work on Indian insects.

Insect Collection.

Taking into consideration the area of our vast country and tremendous variety of insect life, and recognizing the fact that perhaps we do not know even one insect in sixty, our task is stupendous. We require an army of enthusiastic, careful collectors and investigators. The only paid staff for purely taxonomic work in Entomology in India consists of one Assistant Superintendent in the Zoological Survey of India and his small staff and one Systematic Entomologist attached to the Forest Institute, Dehra Dun. How utterly and hopelessly inadequate this staff is, needs no advocacy. Investigators on medical entomology have done excellent taxonomic work on small insect groups of medical value and some taxonomic work has also been done in Agricultural Institutions and the Universities, but the fact remains that today most of our taxonomic work is being done by experts, outside the country.

In the past in every country taxonomic entomology has been the outcome of the enthusiasm of amateurs and our country has been no exception. We owe a deep debt of gratitude to those enthusiastic workers, including clergymen, army men, medical men and others, who while engaged in their own pursuits, found time to collect insects and study them. Most of these voluntary workers have been Europeans, particularly Britishers. Among early collectors of Indian insects and taxonomists one looks in vain for an Indian name. Even today there is hardly a country-man of ours who is known to collect insects as a hobby. Time has come when we should shoulder this burden, and it is our duty to encourage amateur entomologists.

It is not every one interested in insects that becomes a keen collector. It is therefore essential to promote the habit of insect collecting from the very childhood and for this purpose we must go down to schools. Insect collections must form an important part of nature study and every teacher passing through a training institution must provide proof of his being able to encourage insect collection by personal example. It has been claimed for entomology 'that it can procure the maximum delight for the mind' and believing in this we must initiate others to the delights of entomological pursuits. Insect collection should be as interesting a hobby as stamp collecting and infinitely more useful.

According to Sharp (1919) 'This period ought in the history of Entomology to be marked as the age of collecting', and he states that 'to get together a collection of all the insects of a limited region is merely to lay one of the foundation stones of science of Entomology in that region'.

Insect Survey.

Geographical and ecological distribution is in itself a fascinating subject and it is of utmost importance in applied entomology

—medical, veterinary, agricultural or forest. Epidemiology is already considered a very important branch of medical science and it is being recognized as of great importance among workers in every branch of applied entomology. A complete survey, geographical and ecological, is necessary for a proper study of the epidemiology of all pests, and must be encouraged by every possible method. In addition to pest surveys, general insect surveys are necessary as these form the foundation of taxonomic work. All institutions teaching advanced entomology should organize such surveys and by every possible means such surveys should be encouraged.

Universities and Taxonomic Entomology.

Our Universities can play a very important part in conducting insect surveys, in getting together large collections of insects and in developing taxonomic entomology. Every University in India where there is a Department of Zoology should undertake a thorough entomological survey at least of a group of insects or a geographical region or an ecological complex. We shall thus lay the foundation of excellent taxonomic work in all parts of our large country.

It should be recognized that taxonomic work is of fundamental importance in the training of an entomologist whatever line of work he may take up later on. Before an investigation is started, may it be in bionomics, physiology, ecology, distribution or applied entomology, we must be able to answer precisely, definitely and without a shadow of doubt the question: 'What is it?' Let every student of entomology develop sufficient keenness and enthusiasm for taxonomic study, so that he realizes the importance of this question. Not only should all taxonomic work of merit be recognized for all University degrees obtained through research but it should be specially encouraged. To further emphasize the point I would draw your attention to the following resolutions moved by Horn-Escherich—Nuttall, at the International Congress of Entomology (1925). That:—

'The teaching of Systematic Entomology at Universities be adequately provided for by the establishment of chairs especially devoted thereto.'

'The meritorious systematic work should be regarded as qualifying candidates for ordinary and advanced degrees at Universities.'

Museums.

Taxonomy and insect collection go hand in hand. In order to obtain quickly an accurate determination of insects, properly classified, named collections for comparison are absolutely essential. In every province and Indian State there should be an Institution or a Museum, with an adequate staff of

specialists and technical Assistants for taxonomic work. As long as this is not done taxonomic entomology must remain undeveloped. Such an Institution will serve as a repository of collections of all species in a particular area, will exchange duplicates with other similar Institutions and thus taxonomic entomology all over the country will develop. Whether these museums are independent institutions or form part of Agricultural Colleges or the Zoological School of a University is immaterial.

Further, we should develop at least one National Museum which should have as complete a collection of Indian insects as possible. India has lost almost all types of insect species so far described. Let us have the next best—carefully determined, properly labelled, authentic specimens of all our insects, so that future investigators have facilities for work. We must make a vigorous co-operative attempt to have at least in one place as large a collection of species described from India as we can.

OTHER LINES OF RESEARCH.

I have laid special stress on taxonomy, but not because I consider it the be all and end all of entomology but because this field of study is not receiving in India, and in fact anywhere else, the attention which its magnitude and importance demand and deserve. In our country there is need for research in every branch of entomology. We must study the morphology of Indian types and place in the hand of our students books dealing with the structure of insects that exist in this country. In Entomology we should have Monographs of the type issued from Lucknow (edited by Bahl). Our studies in bionomics have been confined to few pests and a great deal remains to be done. Fletcher's studies on the life-history of Indian Microlepidoptera just indicate what is required for all the groups. Insect psychology, or to use a simpler language, studies in insect tropism or behaviour, are of utmost importance. If we can only discover what force guides the female Carpet beetle—*Anthrenus*, an open air insect to enter a house, however well screened with wire gauze, reach the deepest recesses of cupboards, creep in through narrowest chinks, and get at woollen garments, or, if we can discover what attracts the female *Anopheles* to man, we would be well on our path to a satisfactory control of most insect pests. Insect ecology holds the field today and it must play an important part in placing in our hands facts on the basis of which we could predict insect abundance and outbreaks. Enormous work is needed in this direction. Biological control of insect pests is yet in its infancy in India. We know very little about enemies of insects and their mass multiplication. We know still less about insect diseases. Insect pathology is a young science and full of promise. And finally we must not ignore the application of mathematics and statistics to our science, use of logarithmic

tables has entered the field. The demand is so great and so much work is to be done that we cannot get enough workers and enough facilities for the study of all the different aspects of insect life.

FUTURE OF APPLIED ENTOMOLOGY.

As a result of general awakening to the applied value of entomology and improvement in the teaching of entomology, it is expected that more money and more men will be available for researches in this direction. In every branch of applied entomology there is need for great and immediate expansion. If India is to rise then her insect pests must go under. Any money spent for the study of insect pests will more than repay itself. In every province and in every Indian State more men are required for investigation on insects of agricultural, medical and veterinary importance. In every province an entomological section of the Department of Agriculture is a necessity. Every Medical Department and Veterinary Department should have fully trained men available for investigation of local problems and control of disease carriers. Our Forest Entomology needs strengthening. I wish to draw your particular attention to one danger. The line between pure entomology and applied entomology has no thickness, but very often an applied worker has to stop work of great importance, because the pay-master considers it pure science and will not see its future possibilities. This is the case all over the world, but more so in India. The consequences of such a policy are as serious for the development of science as for the intellectual development of the workers.

ENTOMOLOGICAL LITERATURE.

It can hardly be disputed that no branch of knowledge can progress without literature. In this respect entomology in India is very badly placed. We have no literature worth the name in any of the vernaculars of our country. Without such a literature we cannot interest our people in this very important science. There is need for simple, popular books on insects in general and also on insects which do damage to our crops, our goods, our animals and injure ourselves. Since 1909 when Lefroy wrote his 'Indian Insect Life' no comprehensive book has been published on insects of India, and Lefroy's book has been out of print for years. Thus Indian students of entomology have to fall back on books dealing with insects of other countries. It will be a fit tribute to the memory of Lefroy, who did more for entomology in India than any one else, if his book is revised and brought up-to-date. There is need for scientific treatise on applied entomology with reference to the particular conditions of the country. Abundant material is available and time has come when this work should be taken in hand.

There is enormous literature scattered in numerous journals and publications dealing with Indian insects and a complete bibliography of this literature is one of the greatest needs.

The brief and incomplete outline of the history of Indian Entomology that I have placed before you must have shown that there is need for an authentic history of Entomology of this country. Books printed elsewhere ignore our country completely, we must make up this deficiency ourselves.

We must vigorously push forward the publication of the 'Fauna of British India' and Catalogues of Indian Insects.

INTERNATIONAL POSITION OF ENTOMOLOGY.

Entomology has long ceased to be a subject of purely national interest and is becoming more and more a subject of great international importance. Insects recognize no political barriers nor separate governments. Today they conquer one country tomorrow another. Modern means of transport—railways, motor cars, steamships, airships, aeroplanes—have made the spread of insect pests a matter of international consideration. India has already been invaded by San Jose' Scale, American Blight, Potato Tuber Moth, and Codling Moth, to mention but a few. Further, insects such as the locusts born and bred in one country may fly over to distant lands. Nations are awakening to the international importance of insects, and Locust research and control are already in operation on international basis. Therefore, an entomologist, to whatever country he may belong, has to take an active interest in the international entomological problems. With ever increasing quarantine restrictions and legislative measures against the spread of insect pests, demands for certificates of freedom from pests, notification of outbreak of pests on international basis, India must develop her entomology so that she can take her proper and rightful place in the international assembly of entomologists. You will be interested to know that the Imperial Institute of Agriculture, Rome have announced that Radio communiques of that Institute will be transmitted for English knowing people on Thursdays.

So far we have gone on the presumption that an insect which can exist in one country can also exist in another and a pest of one country can assume the status of a pest in every country. It is true that some insects have become wide spread in a comparatively short period of time, for instance the San Jose' Scale; and yet there are others which have not been able to spread even into neighbouring territories and adjacent localities. Without a thorough study of the ecology of a species it is impossible to predict its behaviour and in the meantime much money is being spent at our quarantines in killing insects which are either already dead or which if introduced to new locality

are likely to die of their own accord. India if she is to protect herself against foreign pests efficiently⁴ then she must study the question and develop a well organized and well trained quarantine service. This important task can no longer be left in the hands of laymen.

ENTOMOLOGICAL JOURNAL.

For growth of entomology a periodical devoted entirely to the publication of research work in this science is essential. At present there is no such journal in India. Most of the papers on entomology, therefore, find their way into periodicals dealing with general agriculture, forestry, medicine and veterinary, or what is still distressing, into the proceedings of the various Societies and Academies and the publications of the various Universities, intermixed with subjects which are not of the remotest interest to an entomologist.

Sir John Russel mentions in his recent report that 'it is comparatively rare to find references to Indian investigations in books published outside India'. The scattered manner in which we publish the results of our researches is certainly one of the reasons for this unfortunate neglect. Sir M. Visveswaraya in his Presidential address before the Indian Science Congress of 1923, deplored the tendency to multiply our journals, which leads to defusion and disorganization, instead of co-ordination and co-operation. He emphasized the need of one accredited journal or publication for each branch of science, which will command respect in other countries. A rough computation made reveals the fact that no less than 80 different publications in India include material on entomological subjects. Even if half of this material is of general character which should legitimately find its place in popular periodicals, the position still remains unsatisfactory. Is it possible for College and University libraries to obtain all these journals, or is it possible for any research worker to keep track of the literature in the special branch of knowledge in which he is interested? The Scientific Abstracts issued by the National Institute of Science in India and Lists of Publications on Indian Entomology published by the Imperial Council of Agricultural Research, are very incomplete because even the Zoological Survey of India and Imperial Agricultural Research Institute do not get many of the publications appearing in the country which contain valuable entomological material. Workers in medical entomology advocated the desirability of a separate entomological publication very early and in the very first meeting of the Governing Body of the Indian Research Fund Association the question of publishing an Entomological Bulletin was raised. Evidently the Entomologists being in minority lost the point and it was decided that entomological papers should be published in the Indian Journal of Medical Research. Hundreds of pages of this Journal have been devoted to first rate entomological

literature, dealing with physiology, morphology, ecology, bio-nomics, embryology and taxonomy, intermixed with, for instance, such subjects as Birth and Marriages among Brahmans. Thus most valuable entomological material has become out of reach of many entomological research workers. Similarly, we find excellent entomological literature in agricultural and forestry journals, buried among heap of other matter.

Almost two decades back the following resolution was passed by the Third Entomological Meeting held at Pusa (1919) :

‘The Third Entomological Meeting is of opinion that it would be desirable to have a Journal solely devoted to Entomology and Government should undertake publication of it

The details were left to a Committee, but as most of the members proposed for this Committee declined to serve on it, the matter had to be dropped.

Lately the Forest Entomologist has at last been successful in getting a separate publication on Entomology.

It is evident that a periodical which should collect the best of all the available entomological material and publish it in a form readily accessible to all entomological workers, would be eminently desirable and would meet a real and pressing want. Such a periodical besides collecting valuable entomological material in one place, will enable workers to find out what others are engaged on, co-ordinate work, excite healthy emulation, and let the outside world know what Indian Entomologists are doing.

ENTOMOLOGICAL SOCIETY.

So far no serious attempt has been made to have an organization to provide a common meeting ground for all those interested in insect study. The nearest approach were the Entomological Meetings arranged by Fletcher, the fifth and the last of which was held in 1923 at Pusa. It is after 15 years that we meet again in this Section.

While in the year of grace 1938 we have to consider the question of an Entomological Society for India a number of Entomological Societies have completed one hundred years of active work, and some have a still longer record of useful service.

It will not be without interest to state that the first Entomological Society to be founded was Societas Aureliana of England, established in 1745. The Societas Entomologica, which developed into the Royal Entomological Society, London came into being in 1806.

Entomological Societies were established in America in 1842, in Russia in 1861, in France 1867, in Canada 1868, in Argentine 1873. The Royal Entomological Society of Egypt was established in 1907.

It is most necessary for the future development of our science that a powerful, independent body of Scientific opinion be created to foster the growth of entomology in our country. An Entomological Society of India with branches all over the country is greatly needed.

GENTLEMEN, 'much has been done but much more remains to be done', and let us turn to our task with the full conviction that :—

'The entomologists are the men on whom the world must depend for much of its future prosperity', Howard (1925).

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